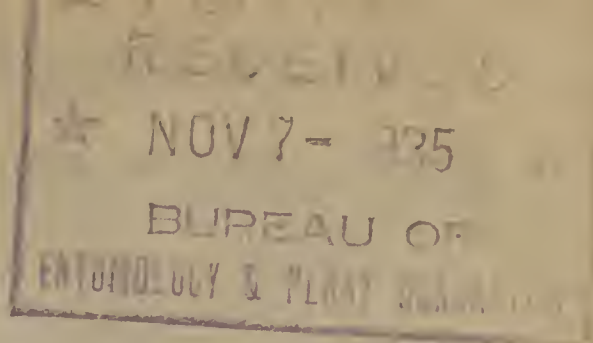


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REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY, 1934

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D.C., August 31, 1934.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1934.

Respectfully,

LEE A. STRONG, *Chief.*

Hon. HENRY A. WALLACE,
Secretary of Agriculture.

On September 30, 1933, C. L. Marlatt, who had been Chief of the Bureau of Entomology since October 16, 1927, reached retirement age and left the service after 45 years in the Department of Agriculture.

CHANGES IN PERSONNEL

On January 16, 1934, P. N. Annand was made chief of the Division of Cereal and Forage Insects and W. H. Larrimer was given charge of the cereal and forage insects laboratory at Arlington Experiment Farm. The act carrying appropriations for the fiscal year 1935 provided for the consolidation of the Bureau of Entomology and the Bureau of Plant Quarantine effective July 1, 1934, the new bureau to be known as the Bureau of Entomology and Plant Quarantine. On January 1, 1934, by order of the Secretary, there were transferred to the Bureau of Entomology those functions in the Bureau of Plant Industry concerning the control and eradication of plant diseases and this work also is consolidated in the Bureau of Entomology and Plant Quarantine. A Division of Plant Disease Control was created with Karl F. Kellerman, formerly associate chief of the Bureau of Plant Industry, as chief of the division. In this reorganization, the work of the Division of Stored Product and Household Insects was reassigned to other divisions in the Bureau and the Division of Stored Product and Household Insects as such was eliminated. E. A. Back, formerly in charge of that division, was transferred with the work on household insects to the Division of Insects Affecting Man and Animals. These changes became effective during the fiscal year covered by this report.

INSECTS AFFECTING MAN AND ANIMALS

The work in this division is under the direction of F. C. Bishopp.

One of the outstanding activities in this division during the past year was the large-scale mosquito-control program undertaken under the authority of the Civil Works Administration. This Bureau has indicated in the past that pest mosquito-control work was perfectly practical on a large scale and this was demonstrated in the program mentioned. The program was carried out in 32 States and the District of Columbia, in most cases the State entomologist acting as State director of operations under Federal supervision. Over 1,030 miles of ditches were dug, about 400 miles of stream banks were cleared, deepened, and straightened, dikes to the extent of 53,020 feet were thrown up, and metal and concrete culverts to the extent of 7,566 feet were put in. Fifty tide gates were installed and about 400,000 cubic yards of dirt and rock were removed in the

dredging, filling, and excavating work. Brushy flood areas totalling approximately 7,600 acres were cleared, and approximately 11,000 feet of tile drains were installed.

Carried along with this program was some work on salt-marsh sand flies in the State of Georgia, this being the first known attempt in the history of economic entomology to control this insect. The results show the practicability of control measures and demonstrate the beneficial results.

The cattle grub continues to assess a heavy tax on the cattle raisers, dairymen, packers, tanners, and dealers in hides and leather. The most vulnerable point of attack is upon the grubs in the cysts under the skin of the backs of the cattle. Field work has been directed, therefore, toward developing a larvicide which would be high in efficiency, simple and speedy in application, greaseless to coat of animals, and aseptic.

Serious annoyance of botflies to horses and the injury produced by the bots within the animals has led to the inauguration of control operations. In connection with these control efforts, the need of a more complete knowledge of the life history and habits of the bots became apparent and biological work along these lines has been carried on in Iowa by this division. These studies have developed some rather surprising information which has led to more simple and probably more effective control methods.

Investigations were continued on the American dog tick (*Dermacentor variabilis* Say), which is the principal vector, in the Central and Eastern States, of the disease of man known as Rocky Mountain spotted fever. A Federal Civil Works Administration project in the States of Delaware, Maryland, and Virginia, and the District of Columbia during the past winter gave an opportunity to gather information on the value of clearing up undergrowth and of destroying the small animal hosts in the control of this tick.

Screw worm infestation of livestock in Georgia and Florida was reported for the first time in 1933. Similar infestations in the current year over somewhat wider extent of territory indicate that in this general region the pest has become permanently established. A general survey of the infested area, including the distribution and abundance of the parasites and predators of the screw worm, has been made by the Bureau and advice concerning control measures has been given State and local authorities. The large-scale trapping experiments which have been conducted in Menard County, Tex., were discontinued at the end of the 1933 summer season. E. C. Cushing of the Menard, Tex., laboratory, in collaboration with W. S. Patton, the English medical entomologist, discovered that two species of screw worms, previously undifferentiated, are present over the infested area in this country. Recent field work indicates that the habits and destructiveness of the two species differ widely. This discovery will undoubtedly prove to be of far-reaching importance in connection with the screw worm problem.

Severe outbreaks of buffalo gnats or black flies were reported from the lower Mississippi Valley, where hundreds of mules were killed by this insect. Studies are urgently needed to work out practical and effective control measures.

Work was continued on the eye gnat until the close of the fiscal year, when it was discontinued on account of lack of funds.

Investigations on maggots for use in treating infections of human beings have yielded a method of rearing and shipping which is much simpler and cheaper than those previously employed. This will doubtless result in the more extensive use of this highly successful treatment.

JAPANESE AND ASIATIC BEETLE INVESTIGATIONS

The work in this division is under the direction of C. H. Hadley.

A committee consisting of W. C. O'Kane, deputy commissioner of the Department of Agriculture of New Hampshire, chairman; W. E. Britton, State entomologist of Connecticut; T. J. Headlee, State entomologist of New Jersey; H. B. Weiss, chief, Bureau of Statistics and Inspection of New Jersey; P. J. Parrott of the New York State Agricultural Experiment Station, and Charles H. Richardson of Iowa State College was appointed in January 1934 to make a survey of the work of this division. The committee found the work progressing satisfactorily but recommended that certain lines, notably the insecticide work, be strengthened.

The winter of 1933-34 in the area where the Japanese beetle is prevalent was characterized by abnormally low temperatures and heavy snows. Contrary to the general impression, however, there is no evidence that the cold winter weather caused any marked reduction in the grub population throughout the area as a whole. Considerable progress has been made during the year in the colonization

of imported parasites of the Japanese beetle at a number of points in the generally infested area. Further studies of mechanical traps for catching Japanese beetles resulted in developing greater efficiency in this work. Tests with the cheaper grades of geraniol as the primary bait for Japanese beetle traps have shown that some of the cheaper grades are as attractive to the beetle as the more expensive grades heretofore recommended.

Work was continued in the effort to develop effective stomach-poison insecticides for the Japanese beetle. Investigations as to the tolerance to chemical treatments of certain types of nursery plants were also continued in order to assist in the movement of plants from the infested area to noninfested areas without the danger of carrying infestations.

The Asiatic garden beetle (*Autoserica castanea* Arrow) continued to spread to the westward on Long Island and in Westchester County, N.Y., and in suburban areas immediately adjacent to Philadelphia. The insect was found for the first time in both the northern and central sections of New Jersey. The remarkably low temperatures experienced on Long Island and other areas of general infestation failed to bring about any noticeable reduction of the larval population of the insect.

BEE CULTURE

The work in this division, which is under the direction of J. I. Hambleton, covers phases of apiary management, honey and wax production, and also the use of honeybees in the pollination of orchard and farm crops. A survey of honey-production cost and management was made during the past year in cooperation with the University of California. A similar study was made in cooperation with the Oregon Agricultural College as well as in the white-clover region around the Great Lakes.

In cooperation with the Railway Express Co., a number of trial shipments of package bees have been made from shipping points in the South to destinations in the North in an effort to ascertain the causes of heavy losses of package bees and queens in transit. This study was undertaken at the request of the express agency and the shippers of package bees.

Bacteriological work has been continued on *Bacillus alvei* and *B. para-alvei*, the causative organisms in European foulbrood and para-foulbrood. No new outbreak of para-foulbrood has been reported during the past year and information received from the State apiary inspectors in States in which this disease has been found indicates that an encouraging degree of control has been obtained when control methods effective in European foulbrood have been adopted.

More than half of the several hundred samples of disease diagnosed at the Somerset, Md., laboratory have proved to be American foulbrood, indicating that in spite of the general adoption of the plan to burn infected colonies, the disease still continues to exact a heavy toll of colonies. With less money available in the States for bee-disease control, it would appear that the bee-disease situation is apt to get worse. Studies have been continued of the behavior of bees in California in connection with the pollination of deciduous fruits.

INSECT PEST SURVEY AND PUBLIC RELATIONS

The work in this division is under the direction of J. A. Hyslop.

INSECT PEST SURVEY

The object of the survey is to collect detailed information on the distribution and abundance of insect pests and to study these data in relation to the ecological factors which might be used in forecasting insect outbreaks. For example, in the Summary of the Insect Pest Survey Bulletin for 1933, maps were published showing the regions likely to be severely infested by grasshoppers and chinch bugs, which were used in putting on control campaigns this year with special funds appropriated by Congress. These data, particularly the file on foreign pests, are also of value in regulatory work. During the year about 18,700 notes, of which 11,700 were on domestic and 7,000 on foreign pests, were added to the files, bringing the total number of notes up to 207,000.

The monthly Insect Pest Survey Bulletin, including an annual summary of insect conditions, and an index to the bulletin were published. Maps on the distribution of insects were prepared; and publicity work, including the press, radio, exhibits, and motion pictures, was carried on by this office. Fifty clip-

sheet items were issued; 36 entomological articles were released to the newspapers; and 10 talks on entomological subjects were prepared by the Bureau for use in radio broadcasting.

PUBLIC RELATIONS

This office acted as the contact organization for cooperative extension work in entomology between this Bureau and the Office of Cooperative Extension Work. Three extension entomologists were employed part of the year and one the entire year. In addition to regular subject-matter specialist work, these men assisted in the grasshopper, chinch bug, horse bot, and screw worm control campaigns put on by the Bureau during the year.

FOREIGN PARASITE INTRODUCTION

The work in this division is under the direction of C. P. Clausen.

ORIENTAL FRUIT MOTH PARASITES

The importation of parasites of the oriental fruit moth from Japan and Chosen (Korea) was continued during the year. During this period a total of 12,931 adults and immature stages of 12 species of parasites were forwarded to the United States. In addition to these, 120,462 field-collected larvae in cocoons were shipped. The parasites contained in this material were reared out at the fruit moth laboratory at Moorestown, N.J.

JAPANESE AND ASIATIC BEETLE PARASITES

Rearings and collections of several species of parasites were continued on a relatively small scale. Of the parasites of the Japanese beetle, 6,165 puparia of the tachinid fly *Centeter cinerea* Aldrich and 28,380 reared cocoons of *Tiphia vernalis* Rohwer were shipped to the United States. In addition, 5,066 reared cocoons of *Tiphia* sp., parasitic upon the Asiatic garden beetle, and 2,909 adult females of another unnamed *Tiphia*, which attacks the grubs of the imported *Serica*, were forwarded for colonization.

ELM LEAF BEETLE PARASITES

Due to the consistent failure of the European egg parasite of the elm leaf beetle to become established in the United States, an effort is being made to secure the Japanese form (*Tetrastichus* sp.) which attacks the eggs of the beetle in Japan. A total of 1,112 field-collected egg masses were forwarded, and the parasites will be colonized in California under a cooperative arrangement with the State experiment station.

SHIPMENTS OF PARASITES TO FOREIGN COUNTRIES

Assistance has been given to the entomological organizations of a number of foreign countries in the distribution and colonization of various insect parasites of which they have requested shipments. The list of pests, with the parasite species and the countries to which they were forwarded, is shown in table 1.

TABLE 1.—*Pest parasites shipped to foreign countries*

Pest	Parasites	Country
Oriental fruit moth.....	{ <i>Trichogramma minutum</i> Riley.....	Canada.
	{ <i>Macrocentrus ancylicivorus</i> Roh.....	Italy, Japan.
	{ <i>Macrocentrus delicatus</i> Cress.....	Italy.
	{ <i>Glypta rufiscutellaris</i> Cress.....	Japan.
	{ <i>Pristomerus ocellatus</i> Cushman.....	Do.
Pink bollworm.....	<i>Microbracon brevicornis</i> Wesm.....	Mexico.
Codling moth.....	{ <i>Ascogaster carpocapsae</i> Vier.....	Canada.
	{ <i>Phanerotoma tibialis</i> Hald.....	New Zealand.
Woolly apple aphid.....	<i>Aphelinus mali</i> Hald.....	Colombia, Costa Rica.
White grubs.....	<i>Scolia manilae</i> Ashm.....	Mauritius.

COTTON INSECTS

The work in this division is under the direction of R. W. Harned.

A committee consisting of W. E. Hinds, entomologist of the Louisiana Experiment Station, chairman; Z. P. Metcalf, entomologist of the North Carolina Experiment Station; S. Marcovitch, entomologist of the Tennessee Experiment Station; and M. S. Yeomans, State entomologist of Georgia, was appointed in January 1934 to make a thorough survey of the work of the Division of Cotton Insects. The committee spent several weeks in an intensive study of the cotton-insect investigations. After surveying the work at the field stations and conferring with the men in charge of each activity, the committee submitted a comprehensive report containing many helpful suggestions and recommendations. The following is quoted from the report of the committee:

The laboratories and offices of the Bureau stations were carefully inspected and found in excellent condition. Every facility was given the committee to go into the work in every detail. The committee is strongly impressed with the soundness and importance of the Bureau program on cotton insect control. Unquestionably this program includes all insect species which might be classed as of highest importance generally in connection with the production of cotton. In no case is a project involved which might be considered as strictly local in importance. Every project, except *Thurberia weevil*, involves insect damage in two or more States, and most of the projects are of distinct importance throughout the entire Cotton Belt.

In no State did the bollweevil cause as much loss in 1933 as in 1932 but weevils increased in numbers late in the season and in many sections the fall population was greater than normal. Low temperatures during the winter of 1933-34 caused low survival of weevils in the Carolinas, while, due to the mild winter in Louisiana and adjoining States, the survival there was high.

During 1934 the bollweevil infestations were spotted. The heaviest infestation developed in Louisiana, Mississippi, and southern Arkansas. Here the early prospect of unusual abundance of bollweevils and the prospect of better prices for cotton caused more general use of calcium arsenate to control the weevil than for several years past and many airplane dusters were used.

The plats dusted with calcium arsenate at Tallulah, La., gave an average increase of 419 pounds of seed cotton per acre, or 45.4 percent. Mixtures of calcium arsenate and paris green and calcium arsenate and copper arsenite also gave good results. At Florence, S.C., a mixture of equal parts of hydrated lime and calcium arsenate gave as good results when used at the rate of 8 pounds per acre as pure calcium arsenate at the rate of 7 pounds per acre, and a mixture of 1 part calcium arsenate and 2 parts of hydrated lime at the rate of 9 pounds per acre gave promising results. The results obtained in South Carolina from these mixtures, if verified by future experiments, will help the cotton growers of that State by reducing expenditures for calcium arsenate, by reducing the danger of soil injury from arsenic, and by reducing the danger of plant lice infestations that often follow heavy dosages of calcium arsenate.

To determine the effect on succeeding crops of the application of calcium arsenate to the soil, for the third year in succession it was applied to a plat at Tallulah, La., at the rate of 400 pounds per acre. The yield in 1933 was at the rate of 1,501 pounds of seed cotton per acre and the yield on the untreated check plat was 1,459 pounds.

Because of the saving in labor that would be made if cotton could be dusted and cultivated at the same time, there is a persistent demand for a method of doing this. In tests conducted at Tallulah about half as much increase in yield was obtained in the plats dusted during the daytime with a duster attached to a riding cultivator as when the dust was applied when dew was on the plants.

Microbracon mellitor was by far the most abundant bollweevil parasite reared at the different stations. *Eurytoma tylodermais* and *Catolaccus hunteri* were next in importance of the 13 species reared.

Cultural control of the pink bollworm by plowing under crop debris in early winter, followed immediately by irrigation, again substantiated previous results of a very high mortality of overwintering larvae as shown by soil examinations. Breeding and colonization work with two species of pink bollworm parasites has been continued. A total of 25,000 *Microbracon brevicornis* were liberated in 1933 at 5 points, 1 in the Laguna district of Mexico and 4 in the Big Bend district of Texas. Releases of over 3,000 adults of *Exeristes roborator* were made in one field at Presidio during September and October 1933. Of a number of insecticides tested to determine the possibility of killing small pink bollworm larvae several gave promising results.

In the tests at Port Lavaca, Tex., in 1933, sulphur dust again proved to be the best and most economical means of controlling the cotton fleahopper. A new experiment in controlling fleahoppers by destroying the principal overwintering

host plant was tried during the winter. Practically all croton plants were cut and burned on 10,000 acres in Calhoun County, Tex., with funds supplied by the Civil Works Administration of Texas. The hopper population was reduced during April and May within the clean-up area as compared to the previous year, as well as in comparison to the numbers present in adjacent counties. However, by the latter part of May, when the cotton was beginning to fruit, there was a large influx of hoppers from outside areas.

The bollworm still remains an insidious pest, as it is not yet understood what factors cause serious sporadic outbreaks. It occurs wherever cotton is grown in the United States but is more serious west of the Mississippi River. Although the infestations in the experimental fields near College Station, Tex., remained very low in 1933 and did not reach 18 percent in any plat, in 14 of the 15 plats dusted with calcium arsenate there was an increase in yield.

Observations made over a number of years show that the *Thurberia* weevil readily transfers to cotton in sufficient numbers to cause commercial damage when grown contiguous to infested *Thurberia* plants. Dusting with calcium arsenate, as for the bollweevil, gave satisfactory control. In irrigated fields the weevils can be controlled by cleaning the fields in the fall, followed by thorough cultivation and irrigation in the winter or early spring.

No evidence has been discovered that insects aid in the dissemination of Texas root rot of cotton. The cotton wilt fungus was found to pass in a viable condition through the alimentary tract of a number of insects commonly present in cotton fields, including several species of grasshoppers and caterpillars and the larvae of several beetles. The grasshoppers may spread the wilt fungus.

A new line of investigation is a study of the life history and habits of the cotton root aphid in the hope of developing practical control measures. Each year in sections of the Carolinas many young plants are killed or seriously stunted by these insects.

Studies of the life history, habits, and control of the field cricket were completed and a manuscript prepared for publication. This pest at times inflicts serious damage to young cotton plants during dry periods by feeding on the leaves and terminal buds, and on the cottonseed in open bolls.

INSECTS AFFECTING FORESTS, INCLUDING THE GYPSY MOTH AND OTHER MOTHS

The work in this division is under the direction of F. C. Craighead.

COOPERATIVE SERVICE

One of the most important activities of the Division of Forest Insects is its cooperation in insect control with the several Government agencies administering timberlands, such as the Forest Service, National Park Service, Bureau of Indian Affairs, and with such emergency agencies as the Civilian Conservation Corps, the Civil Works Administration, and the conservation program of the National Recovery Administration. Private owners were also aided to a less degree. For the most part this cooperative service consisted in surveys of bark beetle infestations, estimating of losses, recommendations as to methods of control, and furnishing estimates of the cost of such operations.

CONTROL PROGRAMS

The labor made available by emergency relief was applied insofar as practicable to the control of the more serious insect epidemics in which it seemed certain that beneficial results would be secured. Thus 22 of the C.C.C. camps in California undertook bark beetle control work and in the course of the period from July 1, 1933, to April 1, 1934, 9,200 trees with a volume of 8½ million board feet were treated, protecting 350,000 acres of forest. In connection with this work it was necessary to recruit and train about 40 technical men as spotters and insect-control foremen. In addition to the C.C.C. program, control work carried on in various regions under N.R.A. and C.W.A. funds was furnished with expert assistance and advice. In the northern Pacific States and in the northern Rocky Mountains projects against several species of pine-destroying beetles were continued in forests where the high brood mortality due to the excessive cold of the winter of 1932-33 had not rendered such action unnecessary.

In the Eastern States, control work was carried on by C.C.C. camps and C.W.A. labor against various forest and shade-tree insects including the white

pine weevil, European pine shoot moth, gypsy moth, southern pine beetle, and the European elm bark beetle, the latter in connection with the Dutch elm disease eradication campaign.

REGIONAL SURVEYS OF BARK BEETLE INFESTATIONS

The insect-control surveys of the western forest regions, upon which the annual loss is computed and the trend of the infestation is based, were made this year as usual. Much assistance was obtained this year from spotters and control foremen of C.C.C. camps. In some cases some of the more intelligent and interested enlisted personnel of the camps were used.

In general the 1933 survey indicated a reduction in losses in many of the western forests, while in a few an actual increase was recorded. In California the drop in timber losses, while by no means uniform, averaged about 45 percent reduction for the State, and in the northern Pacific States a similar condition was found.

RESEARCH ACTIVITIES

Research activities leading to the development of more efficient and economical control methods against western bark beetles have continued and have resulted in several slight modifications of previous methods. In the East the projects on the southern pine beetle, white pine weevil, locust borer, and other forest insects have been continued and emergency investigations of several other tree pests have been started.

The greatly increased demand for planting stock due to the various afforestation projects of the emergency program has made imperative the control of white grubs both in nurseries and in plantations. A thorough investigation of the problem is now under way which involves not only the study of the biologies and life histories of the several species involved, but also the development of soil poisons which will kill the grubs, but at the same time will not injure the young trees.

A study of possible insect vectors of the recently introduced Dutch elm disease, in cooperation with the Bureau of Plant Industry and conducted under emergency funds from emergency conservation work sources, was started last fall and much expanded this spring. Other cooperating agencies are the New Jersey Agricultural Experiment Station and the Boyce Thompson Institute. The work has not yet resulted in conclusive proof that any of the insects tested are agents in disease transmittal, although experimental work has been done with several, including *Scolytus multistriatus*, *Saperda tridentata*, *Hylurgopinus rufipes*, and *Magdalis* spp. Evidence points to *S. multistriatus* as the most probable vector but positive proof of such a role has not yet been obtained.

Another introduced insect is the subject of investigation in the Northeastern States. This is the beech coccus, which in association with a fungus has caused the death of many beeches in eastern Canada, and during the last few years has spread rapidly in several New England States. In Maine the beech scale, as is also true of several other important tree insects, suffered a nearly 100-percent mortality where it occurred above the snow line, due to the unusually low temperatures of last winter.

CEREAL AND FORAGE INSECTS

The work in this division is under the direction of P. N. Annand.

GRASSHOPPERS

A detailed survey of the abundance of grasshopper eggs was conducted in the fall of 1933 in cooperation with the States of North Dakota, South Dakota, Minnesota, Wisconsin, Wyoming, Montana, and Idaho. The survey indicated that a very severe infestation of grasshoppers could be expected in the spring of 1934, and on this basis Congress made an appropriation of \$2,354,893 for control. The infestation which developed was extremely severe in the States surveyed and infestations requiring control measures also developed in Michigan, Nebraska, Colorado, Utah, Oregon, California, Nevada, Arizona, New Mexico, Kansas, and Iowa. A total of approximately 78,000 tons of poison bran bait was purchased and distributed to the States on the basis of the area infested. The weather during early spring remained cold and generally dry but turned unusually hot during the last of May. This resulted in an enormous hatch of grasshoppers which moved immediately into the cultivated crops and made

necessary repeated applications of bait. The severe drought condition and the poor crop outlook made many farmers unwilling to distribute bait for the control of grasshoppers in areas where no crops were in prospect but, in spite of these unfavorable conditions, satisfactory control was secured pretty largely over the infested area.

The possible substitution of oil for water in grasshopper bait has been further investigated during the present outbreak. It was found this year that the success of the oil bait is dependent in part on the absence of sulphur compounds from the oil used in the mixture. Unsatisfactory results were obtained with some types of oil. It is believed, however, that the cause of this difficulty is now known and the substitution of oil for water in the bait may become generally advantageous in the near future.

MORMON CRICKETS

Outbreaks of the Mormon cricket developed over considerably larger areas than was the case last year. A part of the Custer National Forest was involved in the Mormon cricket outbreak where some 10,000 acres were dusted with arsenicals in the attempt to destroy the marching bands of crickets. Although these were greatly reduced, their extermination was not accomplished and it is believed that further trouble may be expected in the spring of 1935. Infestations of this pest also occurred in southern Washington, and in Oregon, Wyoming, and Colorado.

CHINCH BUGS

The first brood of chinch bugs in the spring of 1934, after doing severe injury to small grains, threatened extensive migration to corn and consequent injury throughout the wide areas in the Missouri and Mississippi River basins. Severe infestation of small grains occurred in Illinois, Missouri, Kansas, Iowa, and Indiana. Lighter infestations occurred in Minnesota, Michigan, Ohio, Oklahoma, and Nebraska. Recognizing the emergency nature of this situation, Congress appropriated \$1,000,000 for the purchase and distribution of material to control chinch bugs. The appropriation became available on June 7, too late for maximum effectiveness since migration from the small grain to corn began the first week of June in many localities. However, more than 6,000,000 gallons of creosote were purchased and distributed and the use of this material in the erection of chinch bug barriers served to save most of the corn from attacks of the first brood, except where invasion of the corn had already taken place. The campaign, as a whole, is considered to have been successful in preventing general severe damage to corn by the first brood and to have demonstrated the effectiveness of the method under conditions of severe infestation.

EUROPEAN CORN BORER

On account of reduced appropriations, the entire European corn borer research program has been reorganized, only those phases being retained that show the greatest promise of practical returns in the near future. These phases include breeding of corn for tolerance and resistance to borer attack, redistribution of the more effective parasites, mechanical and cultural control, and insecticidal control in the more valuable sweet-corn areas, particularly in New England.

SUGARCANE INSECTS

Although the sugarcane beetle (*Euetheola rugiceps* Lec.) is one of the oldest and most injurious pests of the sugarcane in this country, little satisfactory progress has hitherto been made toward its control. It was conservatively estimated that in the spring of 1933 it caused a total loss of at least 25,000 tons of cane in Louisiana alone. Renewed efforts are being made to bring this well-known pest under control, either by artificial or biological control. An effort is being made to establish a parasite which is known to be effective in Puerto Rico on similar beetles and several shipments were made this summer and released in Louisiana. A new vector of cane mosaic (*Aphis bituberculata*) has been discovered at Houma, La., by J. W. Ingram, who is working in cooperation with the Bureau of Plant Industry.

WHITE GRUBS

White grub infestation has continued to progress in importance and presents a problem of major proportions, especially in Wisconsin, Minnesota, and Iowa,

where conditions during the past several years have been steadily growing worse. Serious damage to both pasture lands and cultivated crops over wide areas has been reported from these States.

ALFALFA SNOUT BEETLE

A new alfalfa pest (*Brachyrhinus ligustici* Linn.) of possible major importance has become established near Oswego, N.Y. This insect is a native of central and northern Europe and the grubs of the insect, which is a robust, hard-shelled snout beetle, were found inflicting serious injury to the roots of the alfalfa plants in New York. This was the first recorded appearance of the pest in North America. Surveys made in the spring of 1934 have shown that at least 60 square miles are infested and measures for its control are being studied.

FLEA BEETLES AND STEWART'S DISEASE OF CORN

During the past two seasons a cooperative project between the Bureau of Entomology and the Bureau of Plant Industry has been in progress and the results show that a common and widely distributed flea beetle (*Chaetocnema pulicaria*) which hibernates as an adult and feeds on young corn in the spring carries the organism of Stewart's disease over the winter in its digestive tract and inoculates the corn with this disease. It is suspected that other species of insects may be involved in this process and further studies are progressing to determine this point.

RANGE CATERPILLAR

Work is being continued on the range caterpillar to determine the possibility of controlling it in northern New Mexico by the production and release of parasites on the ranges in the spring. Work is also going forward on the alfalfa aphid in cooperation with the various States and the Bureau of Plant Industry.

IDENTIFICATION AND CLASSIFICATION OF INSECTS

The work in this division is under the direction of Harold Morrison.

The quantity of material handled in the Division of Insect Identification and Classification has again shown a conspicuous increase, amounting to nearly 60 percent over the fiscal year 1933. More identifications have been made this year in every order of insects than in past years, but the conspicuous jump has come in blood-sucking Diptera, due to our cooperation with the Army Medical Museum in a survey of the mosquitoes found in the Civilian Conservation Corps camps. Some 12,000 identifications have been made in this connection and in connection with the Bureau of Entomology's mosquito survey in the Chesapeake Bay area. Despite this increase in identification work, specialists on the staff have succeeded in completing, and in some cases publishing, a number of technical papers on their groups, and definite progress has been made by them in the further organization of the reference collections which they use in making identifications.

INSECT PHYSIOLOGY AND TOXICOLOGY

The work in this Division is under the direction of F. L. Campbell.

INSECTICIDES DERIVED FROM PLANTS

ROTENONE-BEARING PLANTS

Tests against house flies of kerosene extracts of roots of derris, cubé, *Cracca virginiana*, and of haiari stems led to the following conclusions: Rotenone is not the only toxic component of kerosene extracts of rotenone-bearing plants, but it appears to be an important one. A given weight of derris root is likely to yield a larger volume of effective kerosene extract than the same weight of pyrethrum flowers. Pyrethrum extracts are more effective in paralyzing flies, derris extracts more effective in killing them. Kerosene extracts of the samples of *Cracca* at hand were not promising as compared with those of derris and cubé.

Both kerosene extracts and acetone extracts of rotenone-bearing plants were tested to find out the relation between chemical composition of the roots and effectiveness of the extracts against house flies. It was found that rotenone content is usually a good index of insecticidal value, but samples of derris occur

whose extracts are more effective than their rotenone content indicates. The value of these aberrant samples is indicated by the percentage of total acetone extractives or methoxyl content. In the samples of derris and cubé so far studied, effectiveness is correlated on the whole better with methoxyl content than with any other single chemical determination.

In the course of the investigations just mentioned, a rapid method was developed for testing liquid insecticides against house flies. This method is so much faster than the Peet-Grady method now used in commercial laboratories that the household insecticide industry is likely to adopt it.

TOBACCO AND NICOTINE

At the request and with the assistance of the Tobacco Section of the Agricultural Adjustment Administration, experiments were made on the insecticidal value of nicotine in new or untried combinations. Most of this work was done during the winter at Sanford, Fla. Preparations containing nicotine in relatively insoluble form were tested in the laboratory against five species of caterpillars that are pests of truck crops. The purpose of the work was to find out whether any so-called fixed nicotine preparation offers promise of replacing arsenicals for the control of certain truck-crop pests.

The results were not encouraging but facts of considerable interest were brought to light. The five species of caterpillars differed greatly in their susceptibility to fixed nicotine preparations. The greenhouse leaf tier was so resistant that the materials tested would have no practical value against it. The diamondback cabbage worm on the other hand was very susceptible, at least in the first instar. It is doubtful whether any of the materials tested would be effective against mature larvae. In the first instar, the green cutworm (*Lycophotia infecta* Ochs.) was very susceptible whereas another cutworm, the southern armyworm, was resistant. It is possible that cabbage worms could be controlled by fixed nicotine preparations of the nicotine-bentonite type, but present indications are that derris and pyrethrum dusts would be more effective for this purpose. It was surprising to find that nicotine silicotungstate, a compound so insoluble that it is used for the gravimetric determination of nicotine, was, on the whole, the most effective of the materials tested. It was the only nicotine compound that was effective against the southern armyworm and it is suspected that its effect was due more to the silicotungstate radical than to nicotine.

In laboratory tests against mosquito larvae, nicotine was found to be more effective in dilute solutions of sodium bicarbonate than in water. A tobacco extract containing in addition to nicotine other substances extractable from tobacco was no more effective than solutions of nicotine of the same concentration.

MISCELLANEOUS TESTS

Many samples of plant extracts and synthetic organic compounds were tested against mosquito larvae and other insects for the purpose of finding highly toxic materials that might be worthy of further study as stomach-poison insecticides. Nothing of importance has appeared in the tests of plant extracts but progress was made in the synthetic organic compounds. The most toxic compound so far found in tests against culicine mosquito larvae is phenothiazine or thiodiphenylamine. This compound is effective against the larvae at a dilution of 1 part per million in water. No striking results have yet been obtained with it in tests against other insects. All derivatives and substitution products of phenothiazine so far made are less toxic to mosquito larvae than phenothiazine itself. The sulphur in the molecule of this and of other organic compounds appears to play an important part in their toxicity.

TRUCK CROP AND GARDEN INSECTS

The work in this division is under the direction of W. H. White.

WIREWORMS

Investigations on wireworms have been continued in Washington, Idaho, California, South Carolina, and Alabama. Work along control lines has consisted mainly of fumigation with naphthalene, trapping adults, flooding, drying-out of the soil, and crop rotation.

Further observations on the sand-land wireworm control experiments show that the starvation method, which last season indicated would be of value, has not proven successful.

BEAN AND PEA INSECTS

The Mexican bean beetle continues to be the most important pest of beans in the United States, and while its winter survival was slightly less than that of last season, the pest caused considerable damage in certain areas. Both field and laboratory tests of insecticides against this pest have been continued in Ohio, Virginia, and New Mexico.

The tachinid parasite which was introduced from Mexico in 1930 and which has been bred through the winter under laboratory conditions was again liberated in several areas, but so far has not been recovered in the field. The indications are that this parasite will not survive the winter in this country without an alternate host.

The pea aphid investigations were continued in Wisconsin. Owing to the unprecedented weather conditions, the pea aphid not only caused considerable damage in the northern pea-growing areas, but was especially abundant in the pea-growing areas of the Northwest.

BEET LEAF HOPPER

Investigations on the beet leaf hopper were continued in Utah, Idaho, Colorado, and California. The pest caused severe injury to the beet crop in all of the intermountain areas. From early-season indications the prospects were for low leaf hopper populations in the Idaho beet-growing area. However, unexpected numbers of the leaf hopper migrated into the cultivated area, which resulted in the abandonment of a considerable portion of the acreage that had been planted. This influx of the leaf hopper was not due to a development of the pest in the areas which had heretofore been considered as important as contributing to the leaf hopper populations in the beet-growing areas, but to a migration from an unknown distant breeding area. As expected, the leaf hopper was abundant in the Grand Valley and southern Utah. In California the spraying and elimination of the host plants program which was carried on in the San Joaquin Valley apparently reduced leaf hopper damage, as the mild and dry winter experienced would have permitted the large overwintering leaf hopper populations to build up in exceptionally destructive numbers.

SWEETPOTATO WEEVIL

The sweetpotato weevil control project which has been conducted in cooperation with the States of Mississippi, Alabama, Louisiana, Georgia, and Florida since 1918 was discontinued on June 30, 1934. It has been thoroughly demonstrated that crop rotation, the use of certified or uninfested planting stock, the culling of seed potatoes, cleaning up of the fields at harvest, and cleaning up of old storage banks will not only reduce weevil infestations but, if followed systematically, will eradicate the pest from any given farm. The cleaning up of the seaside morning-glories, the wild host plant of the sweetpotato weevil, in the Gulf region and on the islands off the coast of Georgia which was carried on last winter under Civil Works Administration funds will aid materially in the protection of the sweetpotato crop.

TOBACCO INSECTS

The studies on the control of tobacco pests affecting the field crop have been continued in Clarksville, Tenn., and Quincy, Fla. Substitutes for lead arsenate for the control of the tobacco hornworm have been tested, but as yet no satisfactory material has been found.

BERRY INSECTS

The work on berry pests has been carried on principally at the Puyallup, Wash., laboratory against the raspberry fruitworm. Extensive tests with several materials corroborate last season's results in that early applications are more effective in preventing bud damage but that later applications of an insecticide are necessary to reduce fruit infestation.

ARSENICAL-SUBSTITUTE STUDIES

Studies on arsenical substitutes and means of eliminating harmful residues from the market product have been continued at Alhambra, Calif., Baton Rouge, La., Chadbourn, N.C., Charleston, S.C., Columbus, Ohio, and Sanford, Fla. These experiments, which have been mainly with cabbage, substantiated the results obtained last season that treatments with arsenicals or other similar materials

may be continued on this crop up to within 40 days of harvest time without danger of any harmful residue remaining on the market product and also if the cabbage is not treated after the plants begin to form heads. Practically all leaves which develop prior to the time that the marketable head begins to form are discarded at the time of harvest.

Additional tests against the celery leaf tier have shown rather definitely that rotenone compounds are not effective against this insect, and pyrethrum is apparently a specific poison for the pest.

Damage by the pepper weevil has been materially reduced in several areas by the cleaning up of nightshade, the important winter host plant of the weevil. No safe insecticidal treatment has been developed for this pest.

Melon and pickle worm control studies on fall-grown squash have been continued at Charleston, S.C.

GREENHOUSE AND BULB INSECTS

Studies on insects affecting ornamentals and bulbs have been continued at Babylon, Long Island, N.Y., Sumner, Wash., and Washington, D.C. One of the outstanding features from a study of the *Tarsonemus* mites is the fact that it has been definitely established that eight new species of mites are associated with the broad mite and cyclamen mite where formerly only the latter was recognized as a plant pest. While investigations to date indicate that certain of these forms are saprozoic and that their presence on the crop will not necessarily result in primary plant injury, recognition of these species will have a fundamental value in determining the results of control measures against the cyclamen and broad mites.

GLADIOLUS THRIPS

The gladiolus thrips is now widely spread over the country, and where control measures are not practiced, it is causing considerable damage.

MUSHROOM INSECTS

Under this project an apparatus has been developed for the burning of sulphur as a means of destroying insect life in the house prior to the time that the spawn is placed in the bed. This burner operates from the outside of the house and the sulphur dioxide is forced into the house by the means of a centrifugal fan. This burner will eliminate the present cumbersome method of burning sulphur in pans placed in the walks within the house and will also reduce the fire hazard.

PLANT DISEASE ERADICATION

The work in this division was under the direction of the late K. F. Kellerman.

BARBERRY ERADICATION (PREVENTION OF BLACK STEM RUST)

During the past year 563,000 barberry bushes were eradicated on 4,900 properties in the 13 North Central States comprising the barberry-eradication area. Beginning in 1918, Federal and State agencies have eradicated more than 19,000,000 barberry bushes. The result has been a decrease in the annual loss of wheat due to stem rust from an average of more than 57,000,000 bushels for the 5-year period 1916-20 to less than 10,000,000 bushels for the period 1926-30. The number of bushes destroyed by Federal and State agencies during the fiscal year 1933-34 is more than double that of the previous year. The increased activity was made possible by an allotment of funds from the Public Works Administration to the Department of Agriculture for expansion of the stem-rust-control program.

For convenience, activities involved in the stem-rust-control program may be divided as follows: (1) Field observations on rust conducted for the purpose of determining the source, prevalence, and severity of stem rust. The accumulated information serves as a guide to the localities where the most effective use of funds available for barberry eradication can be made. (2) Survey and eradication, which involves locating and destroying bushes in areas where they are growing in such concentration that the efforts of individual property owners are not sufficient to bring about the desired control. (3) Informational activities intended to bring about a better-informed public which will gradually assume more of the responsibility for eradicating bushes that may develop from seed after the original bushes are destroyed.

The following tabulation indicates the trend that wheat losses in bushels resulting from stem rust have taken since the eradication program began. The average annual loss by 5-year periods is as follows: 1916-20, 57,704,000; 1921-25, 17,867,000; 1926-30, 9,641,000; 1931-33, 2,822,000.

SURVEY AND ERADICATION

After 16 years of continuous effort in barberry eradication, remaining bushes are few and scattered in most of the cooperating States west of the Mississippi River. However, in Iowa, Minnesota, Wisconsin, Illinois, Ohio, and Michigan, there are remaining many areas in which common barberries are numerous along rivers and on rough pasture and other uncultivated lands. It is in territory of this kind that the local labor crews have proven most valuable.

Because of the regional nature of the stem-rust-control problem, it is important to this western territory to eradicate barberry bushes in the States immediately to the east. Once rust gains a start near barberries the disease may spread for miles while the grain is still in a succulent stage. During seasons when the weather is favorable for rapid development of the fungus a few barberry bushes in one locality may be responsible for severe rust damage throughout an entire grain-growing area. Thus eradication in any given community or even in any one State has a double purpose: (1) It reduces the amount of local rust inoculum and the resulting damage to grains, and (2) it prevents widespread and destructive epidemics of the disease developing as the result of many small rust spreads coalescing.

Table 2 shows the number of properties cleared and barberry bushes eradicated during the fiscal year 1933-34, and the entire campaign, 1918-34.

TABLE 2.—*Data on barberry-bush eradication in various States*

State	Fiscal year 1933-34		Entire campaign 1918-34	
	Properties	Bushes	Properties	Bushes
	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>
Colorado.....	27	5,351	2,034	60,206
Illinois.....	515	26,981	16,720	2,672,299
Indiana.....	180	5,156	5,787	267,425
Iowa.....	567	33,168	12,113	1,172,678
Michigan.....	647	120,534	12,829	5,926,412
Minnesota.....	528	19,822	6,554	946,310
Montana.....	23	446	464	41,572
Nebraska.....	92	1,793	4,434	144,358
North Dakota.....	10	302	990	30,540
Ohio.....	779	256,253	13,639	2,613,070
South Dakota.....	42	348	1,419	134,840
Wisconsin.....	1,520	92,822	12,999	5,297,462
Wyoming.....	9	244	117	5,424
Total.....	4,939	563,220	90,099	19,312,596

In cooperation with the Bureau of Plant Quarantine, nurseries propagating and shipping barberries into and between the States of the barberry-eradication area are inspected and shipping permits granted those growing only species of *Berberis* resistant to the stem rust fungus.

DUTCH-ELM-DISEASE ERADICATION

During the summer of 1933 an outbreak of the Dutch elm disease was discovered in adjacent portions of New Jersey, New York, and Connecticut, with the center in the vicinity of New York Harbor. According to the best information now available, the disease was introduced in this area direct from Europe within the past few years.

As a result of scouting in the outbreak area during the past fall and winter about 1,500 diseased trees were found scattered over some 1,400 square miles with decreasing intensity outward from the center. An unexpectedly rapid development of the disease took place at the beginning of the growing season in 1934 as a result of overwintering incipient infections which develop rapidly in the new current season's sapwood and which had not developed sufficiently evi-

dent symptoms to be readily detected during this winter-work program. The infected trees began to show serious wilting by May 20 and within a month many of them were dead or dying. During the fiscal year there were found a total of 3,255 such trees in the infected States as follows: New Jersey, 2,012; New York, 1,235; and Connecticut, 8.

Men employed under C.W.A. projects, which supplemented the scouting and eradication activities in the outbreak area during the past winter, assisted in locating and removing the 1,500 diseased trees that could be diagnosed in the dormant season. However, the rapid development of the disease this spring from obscure overwintering infections has made it impossible to perform timely eradication of all of the trees found with the limited funds available to the Bureau and cooperating States. New infections of the current season had not become evident by the end of the fiscal year though it is felt certain that a considerable number of such cases will develop.

The disease has been located at three other points in this country, namely, at Cleveland and Cincinnati, Ohio, in 1930, and at Baltimore, Md., in 1933, and prompt location and eradication of the diseased trees appear to have prevented spread.

PHONY PEACH ERADICATION

The phony peach disease is considered the greatest single menace to successful peach production in the Southeastern States, and is a potential threat to the industry of the entire country. The only known method for dealing with the disease has been found, the destruction of affected trees. In order to meet this situation, a cooperative Federal and State campaign for the eradication of this disease was undertaken, commencing in the spring of 1929. This campaign has now been carried on for 5 successive years, with encouraging results, in view of the fact that it has heretofore been necessary to confine the work almost entirely to the inspection of commercial plantings.

During the 1933 season (fiscal year 1934) regular inspection work was carried out in Alabama, Georgia, Louisiana, Mississippi, and Texas. Out of a total of 1,202 commercial orchards inspected, containing 5,428,498 trees, 761 orchards were found infected, and 31,914 phony trees were found in these commercial orchards. In home orchards, during the same period, 1,949 observations were made; 1,163 of these orchards were found diseased, with 4,640 phony trees. During the 1933 inspection season the total numbers of infected trees found were as follows:

	<i>Trees</i>		<i>Trees</i>
Alabama.....	481	Mississippi.....	350
Georgia.....	33, 249	Texas.....	1, 148
Louisiana.....	1, 326		
		Total.....	36, 554

In central Georgia and Alabama, where the phony peach disease had been gradually spreading and becoming more destructive to commercial peach growing for a considerable period, the disease was becoming established in the wild trees of the region, and in these scattered and unnoticed wild trees, as well as in abandoned orchards, it was building up an increasing reservoir of regional infection. A Civil Works phony-peach-eradication project was undertaken in December 1933 to develop winter work to meet this emergency by clearing out of these heavily infected counties all wild or abandoned peach trees likely to be centers of infection of the phony peach disease. This work was continued as a Federal project until February 15, 1934, and in view of the strong local support of the Federal Civil Works project to eradicate the phony peach disease, these activities were continued as State Civil Works projects until March 29, 1934. The work was carried on in 42 counties in Georgia and 3 in Alabama. Trees were removed as shown in table 3.

TABLE 3.—Peach and plum trees removed in phony-peach-eradication campaign

Kind of trees	Georgia	Alabama	Total
	<i>Number</i>	<i>Number</i>	<i>Number</i>
Abandoned.....	942, 380	136, 671	1, 079, 051
Wild peach.....	2, 765, 530	336, 203	3, 101, 733
Wild plum.....	540, 892	2, 983	543, 875
Total.....	4, 248, 802	475, 857	4, 724, 659

BLISTER RUST CONTROL

Control of the white pine blister rust in the several important white pine regions of the country made satisfactory progress during the past year. This was especially true in the western white pine region of northeastern Washington, northern Idaho, and northwestern Montana where the rust situation is more acute due to the rapid spread and intensification of the disease. In this region the area brought under control almost equalled the total area previously worked. In the country as a whole about 1,045,661 acres of pine-producing land was protected by the eradication of 68,972,384 wild currant and gooseberry bushes, the alternate host plants, which spread the rust to the pines. This work was carried on in cooperation with 31 States and with Federal agencies responsible for the administration of public lands.

The spread of the rust was marked by two important extensions of the known infected area. In the East, the southern limit of pine infection was extended from northwestern Maryland to Augusta County, Va. Diseased pines were located at four points and infection appears to have occurred as early as 1924. In the West, *Ribes* (currant and gooseberry plants) infection was found in Oregon in 12 new locations, 3 of which were in eastern Grant County and represent an eastward extension of the rust. Pine infection was located at 3 points, 1 in Marion County and 2 in Lane County. The infection at Bohemia Mountain in southeastern Lane County represents a southerly extension of the known limits of pine infection and is about 100 miles north of California.

The regular control work of the Bureau was expanded considerably as a result of the allotment of Public Works funds and the use of labor made available by the C.C.C. and the C.W.A.

In the Western States there are two extensive forest regions where the white pines are of great economic and commercial importance, the western white pine region of northeastern Washington, northern Idaho, and northwestern Montana and the sugar pine region of southern Oregon and California. Blister rust is established and rapidly intensifying each year in the western white pine region as indicated by this year's discovery of 13 new pine-infection centers. This brings the total known centers to 90 at the end of 1933. All of them have developed within the last 11 years and there are undoubtedly many others still undiscovered. Control efforts are centered on establishing and maintaining control of the diseases on an area of 3,000,000 acres containing the best of the white pine land and timber. About half of this area is in public ownership. In 1933, approximately 214,976 acres were cleared of *Ribes*, bringing the total protected area to 436,032 acres. It is expected that this area will be increased to over 1,000,000 acres during the current season.

The situation in the sugar pine region is of less immediate urgency but control work if continued would act as a preventive measure to decrease the losses that may be expected once the disease becomes generally established in this region.

The general situation with respect to the control of this disease in the eastern States is quite favorable. In the northeastern region 101,701,527 disease-spreading *Ribes* bushes have been destroyed since 1918 on 9,026,727 acres of land or 76 percent of the control area needing protection. This work has effectively checked the intensification of the rust and the damage to white pines on control areas. A total of 1,150,815 acres or about 10 percent of the control area has been reworked to keep the disease under control and derive full benefit from the work already done.

In the Appalachian region a comparatively narrow belt of white pine extends from Pennsylvania to Georgia along the Appalachian Mountains. The rust is spreading gradually and pine infection is known to occur as far south as Augusta County, Va. *Ribes* in general are more localized and less numerous in this region so that a small amount of timely work should keep the white pine area relatively free of the rust and make it safe for the growing of white pine as a timber crop.

The Lake States region originally contained one of the most extensive and finest virgin white pine forests in the country. There now remain numerous scattered areas of second-growth pine aggregating several hundred thousand acres and in addition white pine is being extensively used in the reforestation of large areas that were severely burned following logging. Blister rust is generally distributed and *Ribes* are present in harmful numbers in white pine stands and on planting sites. Control work has been conducted on such a limited scale in this region that only a relatively small portion of the pine area has been protected.

CITRUS CANKER ERADICATION

Continued observations during the past year in Florida and Alabama, where no citrus canker has been found since 1927, and in Mississippi, where none has been found since 1922, failed to show any infections, indicating that these States have remained canker-free as a result of the effective cooperative eradication campaign carried on since 1915.

In Louisiana and Texas, the disease is persisting at a number of points outside of the commercial districts. In these areas the work is complicated by many scattered dooryard trees, abandoned plantings, and thickets of escaped *Citrus trifoliata* in obscure places, which make complete inspection slow and difficult and give rise to sporadic outbreaks of the disease. Encouraging progress was made in searching out and eradicating these outbreaks, but several years' additional work will probably be necessary before the complete eradication of the disease from the continent can be effected.

Because of scattered infections being found in Texas, a Civil Works project was undertaken in December, 1933, to remove abandoned *Citrus trifoliata*. This was continued as a Federal project until February 15, 1934, and as a State or local project until March 29, 1934. Work was done in 22 counties of the Gulf Coast area; 199,866, or about 85 percent, of the *C. trifoliata* trees in the counties were destroyed. The remainder have been definitely located and plans are being made for their destruction later.

FRUIT AND SHADE-TREE INSECTS

APPLE INSECTS

Last year's report of this Bureau outlined in considerable detail the problem of spray residue and the control of the codling moth (*Carpocapsa pomonella* L.) and pointed out certain of the difficulties involved in working out a satisfactory solution to the problem. Because of the urgency of the situation, the apple-insect allotment has been slightly increased in the face of general reductions in funds. The work has been continued in the field stations at Takoma Park, Md., Vincennes, Ind., Yakima, Wash., and Wenatchee, Wash. In the interest of efficiency the station which was maintained for a number of years at Bentonville, Ark., was consolidated with the station at Vincennes, Ind., in the early winter of 1934.

In the effort to work out a solution of this difficult codling moth problem, a grant of P.W.A. funds in the amount of \$103,215 was made in the spring of 1934.

Approximately half of this allotment has been utilized in conducting three regional large-scale field experiments with various organic materials, such as pyrethrum, derris, and nicotine, in various combinations as possible substitutes for lead arsenate. This work has been located at Parma, Idaho, St. Joseph, Mo., and Kearneysville, W. Va., in cooperation with the agricultural experiment stations of the respective States. In Idaho and West Virginia, the State experiment stations have loaned workers to take immediate charge of the work, and have furnished quarters at substations maintained at the points where the experimental work is under way. For these experiments 20 to 25 acres of orchard in each locality have been leased outright. Experiments with organic insecticides are also being conducted at Hood River and Talent, Oreg. Supplementing the large-scale field experiments, intensive laboratory testing of various organic materials is under way at the regular stations at Takoma Park, Md., and Vincennes, Ind.

In addition, experiments are being conducted on banding and orchard sanitation, in order to obtain more definite information on the exact value of the various so-called supplementary practices, and with the control of the codling moth by the use of the egg parasite *Trichogramma*, which gave favorable indications in preliminary tests at Cornelia, Ga., last season. Large-scale field experiments with bait traps and light traps have also been set up at Orleans, Ind., in cooperation with the Indiana Agricultural Experiment Station. Work with light traps has also been undertaken at Geneva, N.Y., in cooperation with the New York Agricultural Experiment Station. A little attention has also been given to the effect of the various materials on bees, which are an important factor in the pollination of apples.

Observations in the experimental orchards have indicated that a fully adequate solution of the problem will not result from the single season's work, although a great deal of information will be obtained which will be a valuable basis for investigations in subsequent seasons.

PEACH INSECTS

The work of colonizing effective parasites of the oriental fruit moth (*Grapholitha molesta* Busck) is being continued with headquarters at the Moorestown, N.J., laboratory although on a somewhat reduced scale. Apparently as a direct result of the efforts of the Bureau in distributing it, *Macrocentrus ancylivorus* Rohwer is now the most abundant and effective parasite. In many important districts it is the dominant species, almost always being associated with a pronounced reduction in fruit infestation. The plans for the 1934 season include the rearing and propagation of several additional species of parasites from Japan and their colonization in important peach areas, and the making of recovery collections to determine the outcome of previous parasite liberations.

The investigations of bait traps for the control of the fruit moth have been continued at Cornelia, Ga., on a much reduced scale. Further comparisons are being made of various bait materials, and additional practical tests are being made of the better baits in commercial orchards. To the detriment of the experiments, the infestation has turned out to be very light during the 1934 season.

Tests have been made at the Fort Valley, Ga., laboratory of various methods of freeing peach nursery stock from infestation by the peach borer (*Aegeria exitiosa* Say) because of the possible part played by this insect in the dissemination of the phony disease of peach.

GRAPE INSECTS

The work on grape insects has continued as hitherto. Practically the entire attention of the station located at Sandusky, Ohio, has been given to a study of the grape berry moth (*Polychrosis viteana* Clem.), in an effort to develop effective means of control not involving poisonous spray residue at harvest time.

In order to strengthen the work on the grape insects, \$6,000 of the P.W.A. funds granted for spray-residue investigations has been allotted to grape-insect work for an expansion of the 1934 season's program.

NUT INSECTS

The entire nut-insect allotment is now being devoted to a study of insects attacking pecans. The work is conducted at stations at Albany, Ga., Shreveport, La., and Brownwood, Tex. Their activities, however, have been somewhat curtailed. The work of the Georgia Experiment Station, which was making a special study of the pecan weevil (*Curculio caryae* Horn), was discontinued November 30, 1933.

Following the inconclusive results of the 1933 season in the use of the egg parasite *Trichogramma* in controlling the nut casebearer and other pecan insects, a special study is being made at Albany of the behavior of the different strains of the egg parasite, to determine the suitability of these different strains in the control of different pests. With additional funds furnished by other projects, the Albany station has supplied other units in the Bureau with stocks of *Trichogramma* for experiments in the control of other insect pests.

SUBTROPICAL FRUIT INSECTS

The Whittier, Calif., laboratory has continued the intensive accumulation of detailed data necessary as a basis for an understanding of the resistance of the red scale (*Chrysomphalus aurantii* Maskell) to fumigation with hydrocyanic acid gas. Unfortunately, this work has recently been handicapped by the withdrawal of the Bureau of Chemistry and Soils from the project, this action being made necessary by reduction in funds.

Confirming results previously obtained in central California in the control of the citrus thrips (*Scirtothrips citri* Moulton), the first season's experiments in southern California have given very satisfactory control of this species in districts in which untreated groves suffered to the extent of 30 to 60 percent damage.

Investigations of the red date scale (*Phoenicococcus marlatti* Ckll.), the date mite (*Paratetranychus heteronychus* Ewing), and other date pests in the Coachella Valley are expected to be completed at the close of the 1934 season, and manuscripts covering this work are being prepared.

The control of the citrus rust mite (*Phyllocoptes oleivorus* Ashm.) has continued to receive attention at the Orlando, Fla., laboratory.

FRUIT FLIES

The work on the Mexican fruit fly in the laboratory in Mexico City has developed in close cooperation with the Mexican officials who have established a control zone south of the United States citrus area in the Rio Grande Valley. Methods of possible value in such a zone are being investigated jointly. Studies have shown that larvae developing in different fruits resist treatment differently, a fact indicating the desirability of wide study before recommendation. Work with baits has proven that proteins decomposed by strong alkali, or by suitable micro-organisms, give products especially attractive to the guava fruit fly, a lead that may be useful with other insects. A preliminary study of sources and toxicity of *Haplophyton*, a native Mexican plant toxic to the fruit fly, has been made. If the plant could be produced in quantity without variation in its toxic action, it might serve as a useful insecticide source.

At the Honolulu, Hawaii, laboratory, investigations have been continued on the life history, habits, and means for controlling the Mediterranean fruit fly. Much of the work carried on during the last few years has been summarized and technical papers reporting on the results of experiments have been prepared for publication.

Special attention was directed to the summarizing of the extensive studies to determine the effect of high and low temperatures on the immature stages of the fruit fly. Results of these experiments all fully substantiate work previously done and demonstrate that when all types of fruit available in Hawaii or those introduced and infested for experimental purposes are treated so that an inside fruit temperature of 30 to 31° F. is maintained for a period of 15 days, eggs, larvae, and other immature stages of the fruit fly will be killed.

Experiments indicate that the length of exposure necessary to secure mortality varies as much as 72 hours, depending on the composition of the fruit. Experiments to determine the period necessary to hold fruits under refrigeration at somewhat higher temperatures are being continued. Similarly additional experiments to fill in the gaps to determine the period of exposure at temperatures ranging from 107 to 115° F. are planned for the coming season.

Considerable progress has been made in the experiments to develop better attractants with particular attention being devoted to ammonia and protein. In the tests to determine the value of poisons combined with various types of sweetened materials applied to the foliage as sprays, special attention has been devoted to tartar emetic, potassium antimony tartrate, to determine not only its effectiveness on the flies but also its effect on the foliage. Practical tests conducted in mango and citrus orchards confirm the indications from previous work that even under conditions of general infestation which exist in Hawaii, considerable protection can be obtained by repeated applications of such a spray.

The Canal Zone fruit fly laboratory has continued to accumulate data on the biology, habits, and host-fruit preferences of the numerous species of fruit flies present in that area. Some of these species have been practically unknown to science, and the information obtained about them will be of great value in the event any of them should accidentally reach the fruit-producing areas of southern United States.

Mention was made in last year's report of the special studies being conducted at Key West in connection with the efforts made by the Florida State Plant Board to eradicate two species of West Indian fruit flies from the island of Key West, in order to prevent their establishment on the mainland. These fruit flies are now known as *Anastrepha acidusa* Walk. and *A. suspensa* Loew. The results of oviposition experiments indicated that the species *A. acidusa* may successfully attack, under cage conditions, 35 different fruits, including grapefruit, and that the species *A. suspensa* may also attack many of the same fruits. Results of insecticide tests have confirmed the superior merits of tartar emetic as a poison for a bait spray for these two species of fruit flies.

Because of the eradication program, these fruit flies have nearly disappeared from Key West. The work was, therefore, transferred in January 1934 to Puerto Rico, where both fruit flies occur. Further studies are now under way in the laboratory and in the field to determine the host-fruit preferences and habits of the species, and to develop more effective methods of control. The results thus far have continued to indicate that tartar emetic is the best poison for use in fruit-fly baits. Field infestation of *A. suspensa* has been found in citrus fruits in Puerto Rico.

STORED PRODUCT AND HOUSEHOLD INSECT INVESTIGATIONS

The work in this division was under the direction of E. A. Back.

FLOUR-MILL AND GRAIN INSECTS

During the past year the headquarters for these investigations were moved from Kansas City, Mo., to Manhattan, Kans. The cooperation with milling companies has been continued and many checks on practical large-scale fumigations have been made to the advantage of all. Of special interest and value have been the experiments tending to prove the practicability of introducing the fumigant to the machinery itself rather than to the mill spaces from which penetration of the equipment takes place. Experiments have demonstrated that this newer type of fumigation, which can be made without the closing down of the mill in a busy season, may not be quite so effective in the total number of insects killed, but thoroughly practical from the standpoint of preventing clogging of machinery and forced shut-downs for removing the insect-webbed flour, and very much cheaper. Probably 95 percent of all fumigations conducted in flour mills, except those exporting flour, are for the purpose of preventing the Mediterranean flour moth from webbing the flour to the point of forcing the stoppage of operations.

INSECTS AFFECTING DRIED FRUITS

These investigations conducted at Fresno, Calif., have continued to enjoy the hearty cooperation of the California Dried Fruit Association. The results of the work during the past year were considered of such value to the industry that they were published at the expense of the association for distribution to its membership. Of special interest and of practical value is the work conducted in drying yards on the ranches with shields of cheesecloth housed over the fruit during the drying and ranch-storing periods. Done at little cost per ton, the exclusion of egg-laying moths has resulted in making it possible for ranchers to deliver at the processing plant a product that grades high, thus saving to the rancher the cash deductions which now are made with the lowering of grade due to insect presence.

The fumigation of raisins, peaches, apricots, etc., in the stacked trays, etc., on the ranch, under light movable fumigatoria as well as in special fumigating houses, has yielded practical results. Probably no food industry has shown such a pronounced forward step in savings from insect attack on the farm as that made possible on the dried-fruit ranches due to the investigational work of the Department.

THE PEA WEEVIL

The pea weevil has continued as a serious pest in the Northwest, but a survey conducted during the past year in the eastern districts indicates that it is not present there in such destructive numbers. In the Palouse area investigations on control on farms have been very gratifying from the practical aspects. The heavy concentration of hibernating weevils upon the bloom of plants in the border strips planted 3 or 4 weeks before the main crop, discovered and reported upon last year, pointed to the possibility of turning this habit of the weevil into a vulnerable feature of its life cycle. During the past season border crops heavily infested were plowed under to a depth of 8 to 9 inches and then harrowed and cultipacked three times. Cage examinations proved that only 1.7 percent of the original weevil population succeeded in surviving this treatment.

INSECTS ATTACKING CURED TOBACCO

This work, with headquarters at Richmond, Va., has been enlarged during the past year to cope with the problems of the cured-tobacco industry of the Northeast and Middle West, as well as those of the Bright Tobacco Belt, thus unifying the service in a way very gratifying to the members of the Tobacco Association of America.

A representative of the Bureau spent several months investigating the tobacco-storage conditions in the eastern Mediterranean tobacco areas, especially Greece and Turkey, in which Americans have large investments in tobacco, and from which much tobacco of a type not grown in the United States is imported. These imported tobaccos have carried heavy infestations of tobacco pests and the purpose of the trip was to study the storage conditions favorable to insect increase and to institute control measures developed by the Department with a view to

safeguarding American-grown tobacco in our warehouses from contamination from imported tobacco. A study of storage conditions was also made at points in Italy, France, and England.

The perfection and growth in use of light traps in tobacco storage has been an important feature of the past year. The Department's discovery that tremendous numbers of tobacco beetles can be lured and killed in light traps has become popular with the tobacco-storage warehousemen. The initiation of routine vacuum fumigation of all tobacco going into storage has been another of the outstanding developments of the past year. Vacuum fumigation is especially adapted to treatment of baled imported tobacco.

HOUSEHOLD INSECTS

The work with household insects has been confined during the past year largely to continued investigations into the value of fumigable storage for furs and clothing and to moth-proofing solutions. The former work, which has been reported upon previously, has resulted to date in the installation of much control equipment in storage warehouses and department stores. It is believed that the basic investigational work of the Bureau of Entomology with fumigable storage, and of the Bureaus of Entomology and Chemistry and Soils with noninflammable and nonexplosive fumigants only reasonably toxic to man as he comes in contact with them in control work, has resulted annually in the development of a million-dollar business in protecting articles from the attack of fabric pests. This method, being cheap, has greatly broadened the type of clothing that can be protected profitably and has reacted to the benefit of citizens of average means.